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IGNEOUS MINERALOGY

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What are igneous rocks?

The term ``igneous" comes from the Latin word ignis or ``fire". Igneous rocks are rocks which form from cooling magma or lava.

- **Magma**

  Molten or partially molten rock material and dissolved gases.

  Magma is molten rock beneath Earth's surface.

- **lava**

  Molten or partially molten rock material and dissolved gases.

  Lava is molten rock which has erupted at Earth's surface.

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Igneous Rock

Types of Igneous Rock:

Igneous Rocks are formed by crystallization from magma. They include two types

- **Volcanic** or **extrusive** igneous rocks form when the magma cools and crystallizes on the surface of the Earth.
- **Intrusive** or **plutonic** igneous rocks wherein the magma crystallizes at depth in the Earth.

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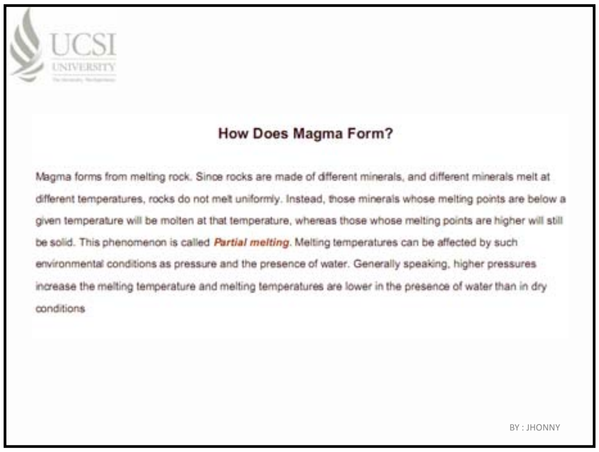

How Does Magma Form?

Magma forms from melting rock. Since rocks are made of different minerals, and different minerals melt at different temperatures, rocks do not melt uniformly. Instead, those minerals whose melting points are below a given temperature will be molten at that temperature, whereas those whose melting points are higher will still be solid. This phenomenon is called ***Partial melting***. Melting temperatures can be affected by such environmental conditions as pressure and the presence of water. Generally speaking, higher pressures increase the melting temperature and melting temperatures are lower in the presence of water than in dry conditions

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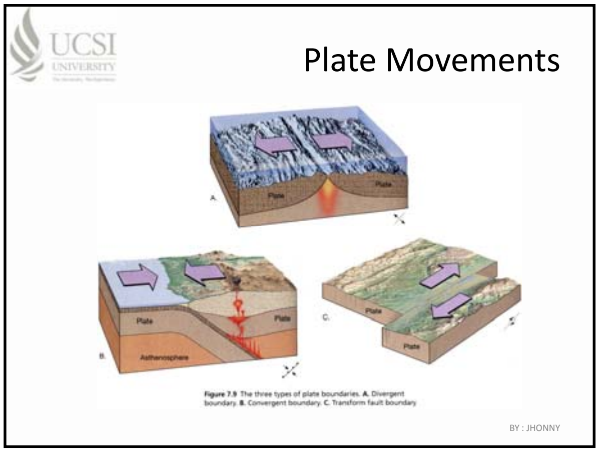

Plate Movements

Figure 7.9 The three types of plate boundaries. **A.** Divergent boundary. **B.** Convergent boundary. **C.** Transform fault boundary

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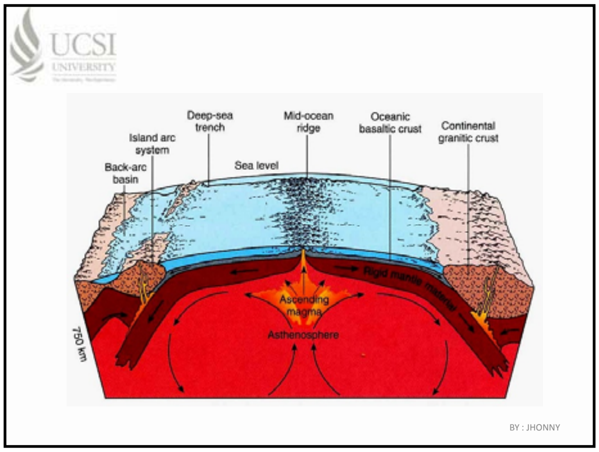

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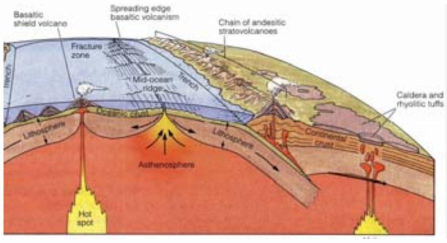
Igneous forming



1. Plate tectonic
2. The cooling of magma

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Generally there are two type of magma:

1. Felsic (acid)
2. Mafic (base)

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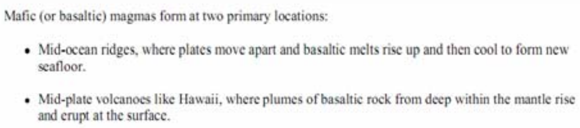

Mafic (or basaltic) magmas form at two primary locations:

- Mid-ocean ridges, where plates move apart and basaltic melts rise up and then cool to form new seafloor.
- Mid-plate volcanoes like Hawaii, where plumes of basaltic rock from deep within the mantle rise and erupt at the surface.

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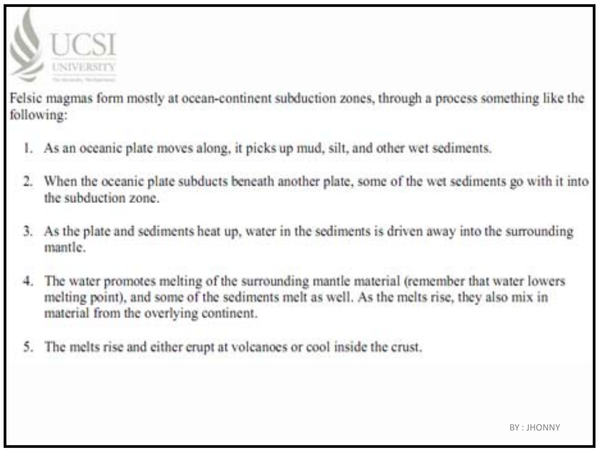

Felsic magmas form mostly at ocean-continent subduction zones, through a process something like the following:

1. As an oceanic plate moves along, it picks up mud, silt, and other wet sediments.
2. When the oceanic plate subducts beneath another plate, some of the wet sediments go with it into the subduction zone.
3. As the plate and sediments heat up, water in the sediments is driven away into the surrounding mantle.
4. The water promotes melting of the surrounding mantle material (remember that water lowers melting point), and some of the sediments melt as well. As the melts rise, they also mix in material from the overlying continent.
5. The melts rise and either erupt at volcanoes or cool inside the crust.

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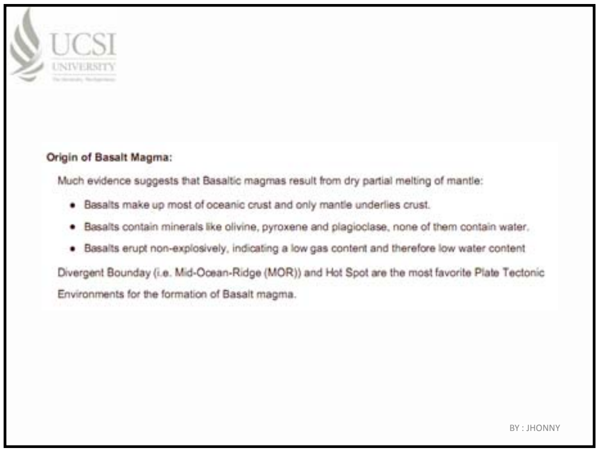

Origin of Basalt Magma:

Much evidence suggests that Basaltic magmas result from dry partial melting of mantle:

- Basalts make up most of oceanic crust and only mantle underlies crust.
- Basalts contain minerals like olivine, pyroxene and plagioclase, none of them contain water.
- Basalts erupt non-explosively, indicating a low gas content and therefore low water content

Divergent Bounday (i.e. Mid-Ocean-Ridge (MOR)) and Hot Spot are the most favorite Plate Tectonic Environments for the formation of Basalt magma.

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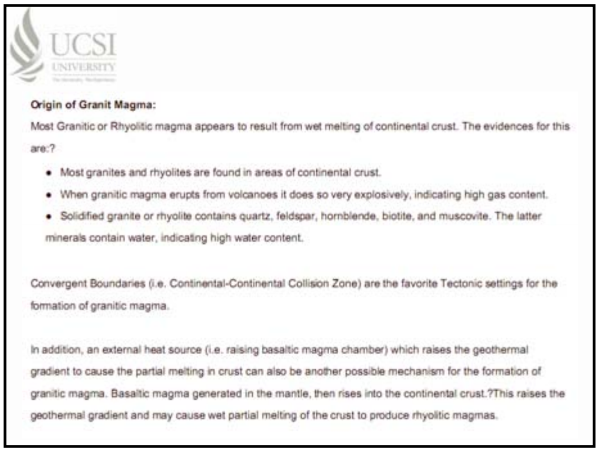


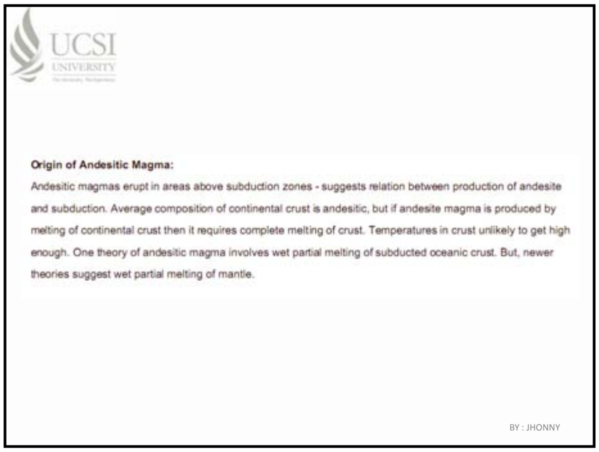
Origin of Granit Magma:

Most Granitic or Rhyolitic magma appears to result from wet melting of continental crust. The evidences for this are:?

- Most granites and rhyolites are found in areas of continental crust.
- When granitic magma erupts from volcanoes it does so very explosively, indicating high gas content.
- Solidified granite or rhyolite contains quartz, feldspar, hornblende, biotite, and muscovite. The latter minerals contain water, indicating high water content.

Convergent Boundaries (i.e. Continental-Continental Collision Zone) are the favorite Tectonic settings for the formation of granitic magma.

In addition, an external heat source (i.e. raising basaltic magma chamber) which raises the geothermal gradient to cause the partial melting in crust can also be another possible mechanism for the formation of granitic magma. Basaltic magma generated in the mantle, then rises into the continental crust.?This raises the geothermal gradient and may cause wet partial melting of the crust to produce rhyolitic magmas.



Origin of Andesitic Magma:

Andesitic magmas erupt in areas above subduction zones - suggests relation between production of andesite and subduction. Average composition of continental crust is andesitic, but if andesite magma is produced by melting of continental crust then it requires complete melting of crust. Temperatures in crust unlikely to get high enough. One theory of andesitic magma involves wet partial melting of subducted oceanic crust. But, newer theories suggest wet partial melting of mantle.

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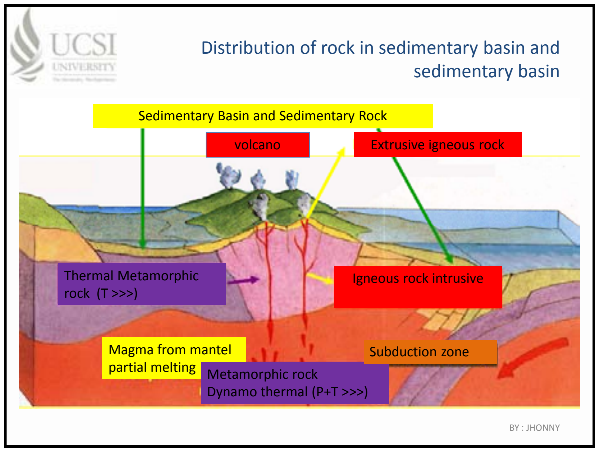

Distribution of rock in sedimentary basin and sedimentary basin

Sedimentary Basin and Sedimentary Rock

volcano

Extrusive igneous rock

Thermal Metamorphic rock (T >>>)

Igneous rock intrusive

Magma from mantel partial melting

Subduction zone

Metamorphic rock Dynamo thermal (P+T >>>)

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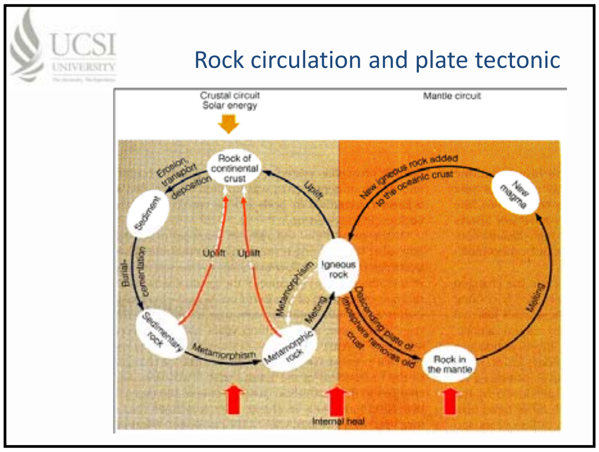

Rock circulation and plate tectonic